Waves and fetch in the Marginal Ice Zone

Jim Thomson
1013 NE 40th St
Seattle WA 98105
phone: (206) 616-0858 fax: (206) 616-5467 email: jthomson@apl.uw.edu

Award Number: N00014-12-1-0113
http://www.apl.washington.edu/MIZ
FY15 report (year 4 of 5)

LONG-TERM GOALS

The long-term goal is to improve prediction of the arctic Marginal Ice Zone (MIZ) by improving basic understanding of the interaction between waves, sea ice, and open water (i.e., fetch).

OBJECTIVES

The primary objective is to improve wave source/sink parameterizations by directly measuring the growth and dissipation of waves in the MIZ. The secondary objective is to develop a surface wave climatology of the arctic ocean and the relation to the seasonal MIZ.

APPROACH

The technical approach is to use Surface Wave Instrument Floats with Tracking (SWIFT) buoys to measure waves, winds, and turbulence at the air-sea-ice interface (Thomson, 2012). The SWIFT deployments were successfully completed during the summer of 2014. These seasonal SWIFT measurements are placed in context using mutliyear subsurface Acoustic Wave And Current (AWAC) moorings and regional WAVEWATCH3 model results.

WORK COMPLETED

Data from six SWIFT buoys operated during the MIZ 2014 campaign have been analyzed. Quality-controlled wave, wind, temperature, salinity, and turbulence results have been posted for use by the DRI team at http://faculty.washington.edu/jmt3rd/SWIFTdata/ArcticOcean/. Additional analysis completed includes removal of noise from the surface turbulence measurements and classification of the onboard images for ice type.

Data analysis has focused on two specific topic: wave-turbulence damping by ice and wave fetch limitation by ice. For the first topic, Figure 1 shows wave spectra and turbulent dissipation profiles separated by ice fraction, with dramatic reductions in the presence of ice. For the second topic, fetch estimates have been made for all wave observations, using a combination of the new MASIE ice edge product when buoys are in open water and the U. of Bremen ice concentration product when the buoys

are in the mariginal ice zone. Student-led publications have been submited to the MIZ special issue on both of these topics: Zippel & Thomson (in revision) and Smith & Thomson (submitted), respectively.

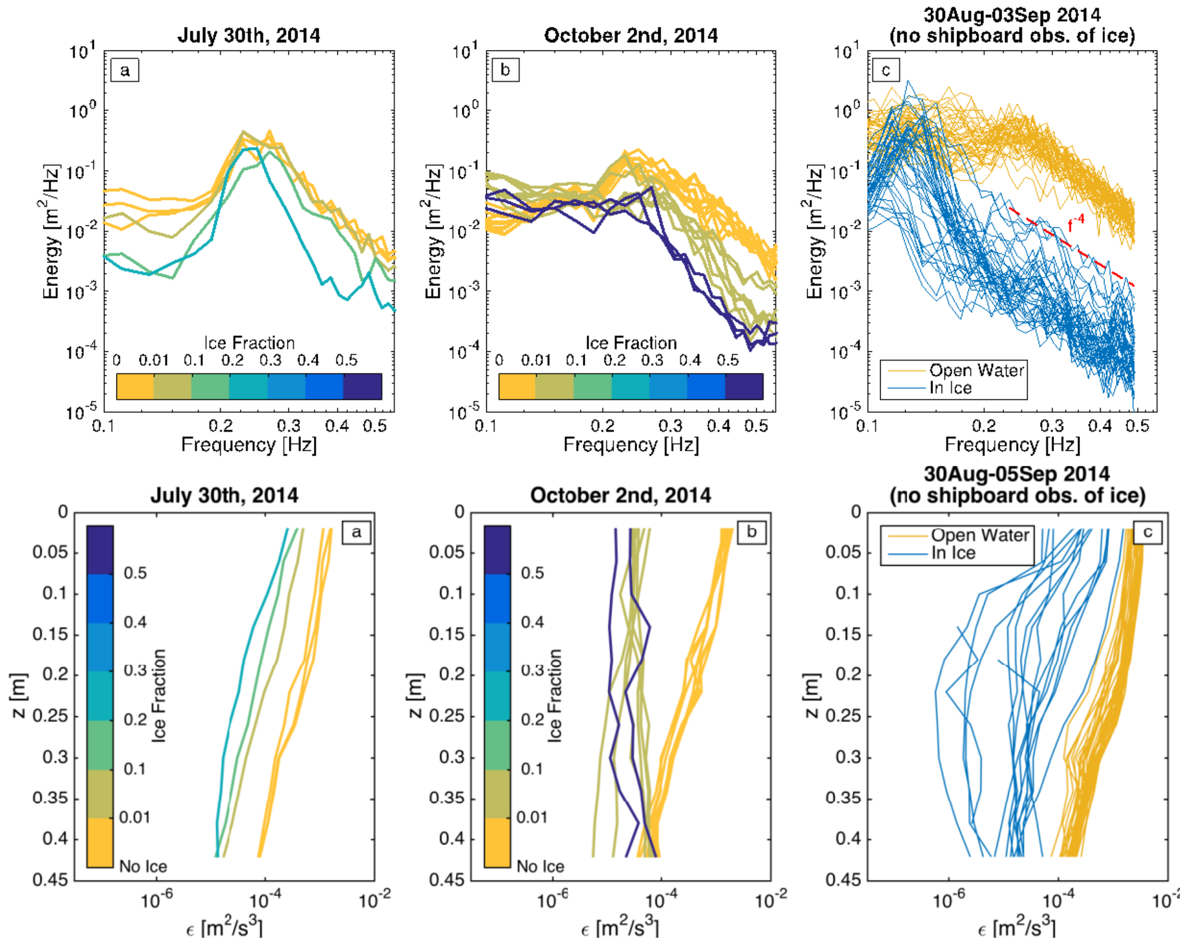

Figure 1. SWIFT wave spectra and turbulent dissipation rate profiles for deployments in the marginal ice zone. Color scale is ice concentration.

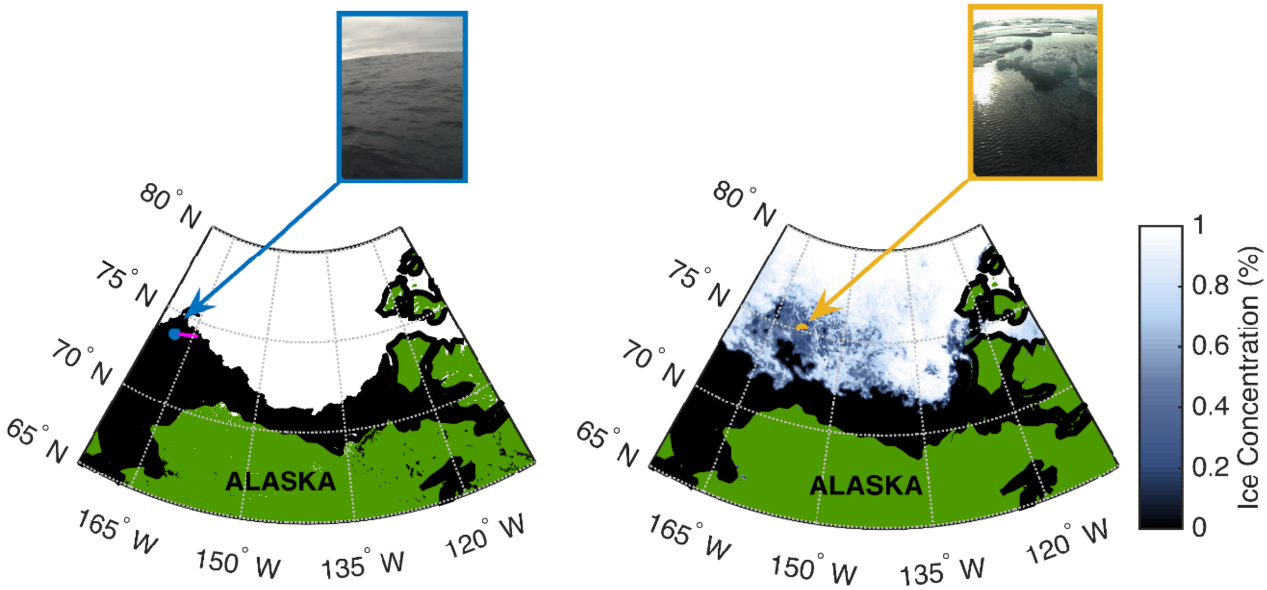

Figure 2. Example estimates of fetch distance analysis in open water and partial ice cover.

RESULTS

The damping of wave-turbulence in ice has been interpreted using the equilibrium theory relating wind forcing to short wave steepness and to turbulent dissipation. For a given wind, both the short wave steepness and the turbulence are damped by the prescence of ice. The damped conditions remain consistent with an equilibrium balance, albeit at much lower levels. Figure 3 shows the effective damping as the ration of the open water equilibrium constant β to a value damped by the ice. The empirical fit to the distance between ice floes is a parameterization of this result that can be applied in models.

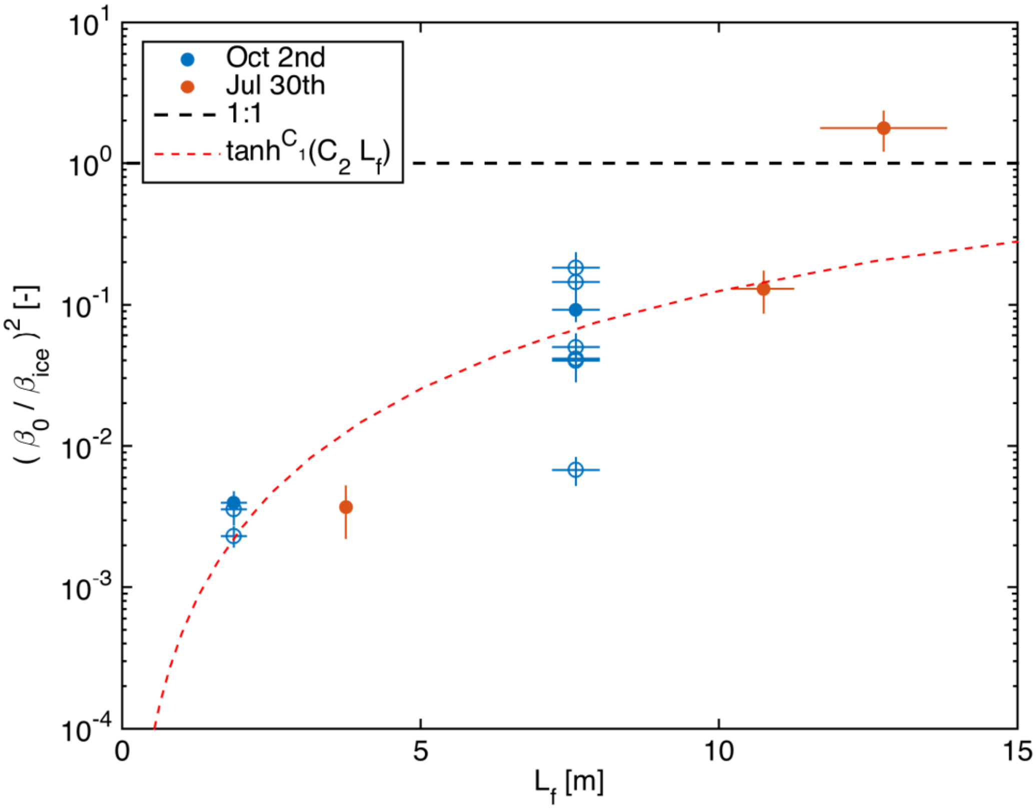

Figure 3. Equillibrium damping coefficent versus the distance between ice floes.

The fetch limitation of waves in the Arctic that has already been shown (with 2012 data) has been refined with the 2014. As shown in Figure 4, the important refinements are to screen the data for storm conditions that are temporality short (and thus the waves are duration-limitted) and to adjust the points in ice using an empirical "effective fetch". These refinements greatly reduce the scatter in the scaling of wave energy with fetch. This approach is also used to re-interpret the 2012 dataset and show that during a year with extreme ice retreat, fetch-limitation may only occur half of the time there are waves.

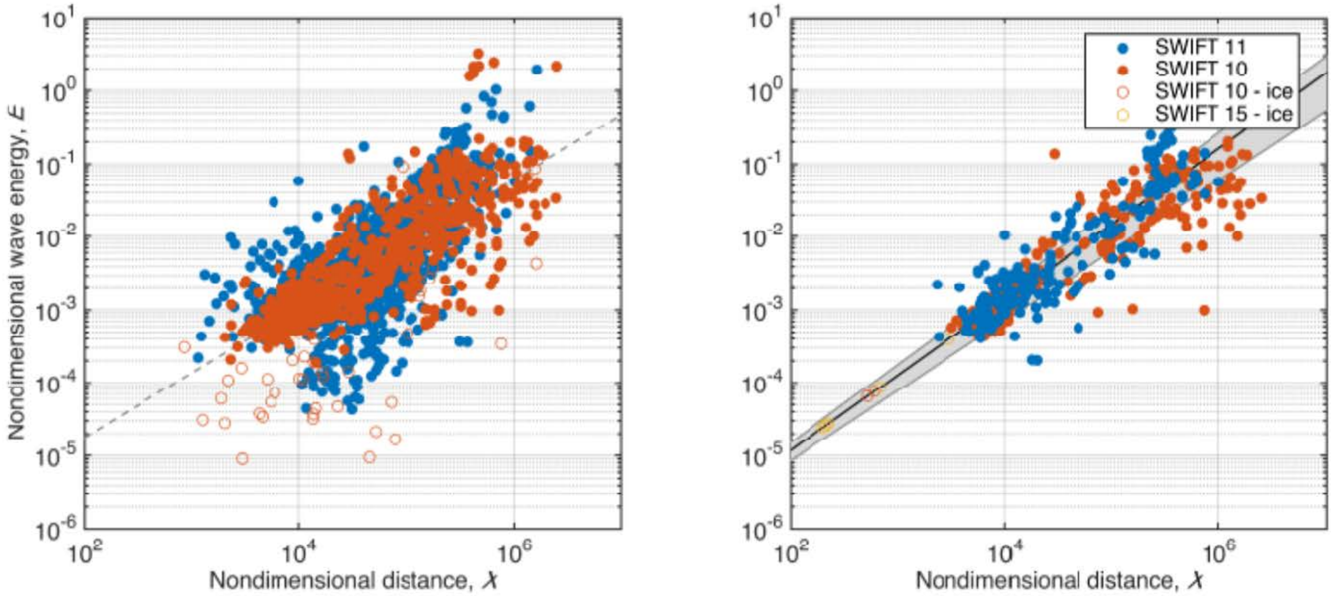

Figure 4. Wave energy, scaled by wind, versus open water fetch, also scaled by wind for the 2014 data set. The left panel includes all points. The right panel includes only points that are not duration-limitted and adjusts the observations in the ice by an empirical correction for ice cover.

IMPACT/APPLICATIONS

Improved wave and MIZ predictions in the Arctic Ocean will enable safe naval operations in the region.

RELATED PROJECTS

Resources and data are shared with the "Sea State and Boundary Layer Physics of the Emerging Arctic Ocean" DRI. More information is at
http://www.apl.washington.edu/project/project.php?id=arctic_sea_state

PUBLICATIONS

Thomson, J. and E. Rogers, Swell and sea in the emerging Arctic Ocean, *Geophys. Res. Lett*., 41 (2014). [published, refereed].

Thomson, J., E. D'Asaro, M. Cronin, E. Rogers, R. Harcourt, and A. Shcherbina, Waves and the equilibrium range at Ocean Weather Station P, *J. Geophys. Res.,* 118 (2013). [published, refereed].

Thomson, J. "Observations of wave breaking dissipation with SWIFT drifters," *J. Atmos. and Ocean. Tech.*, 2012. [published, refereed].

Craig, L. et al, "Science Plan for the Mariginal Ice Zone program," *APL-UW Tech. Report 1201,* 2012. [published].